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TARDEC's Intelligent Ground Systems Overview

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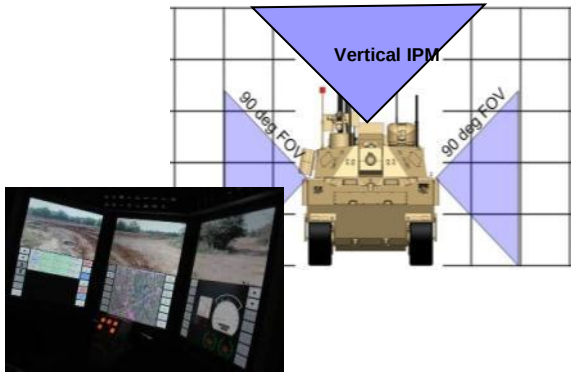
TARDEC Robotics

Autonomous Behaviors

Warfighter Support

III Corps
THE PHANTOM CORPS
AMERICA'S ARMORED CORPS

360° Situational Awareness



Architecture Development & Demonstration

Human – Robot Interface

Safe Operations

TARDEC Robotics

Mission

Integrate, Explore, and Develop Robotics, Network and Control Components with a Focus on Customer Driven Requirements to Provide Full System Solutions to the War Fighter

Technology Components

Integration

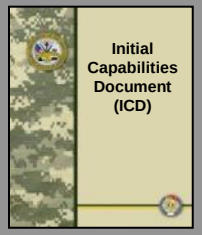
Demonstrators

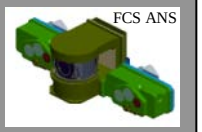
SME Defined Scenarios

Military Relevant Test & Experimentation

Tech Transfer

Transition and Requirements Development





Integration Technology Development Lessons Learned to Enable Early Technology Insertion

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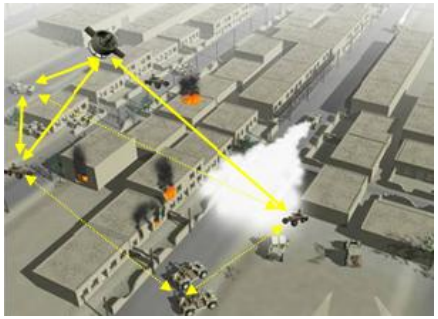
What IGS Does

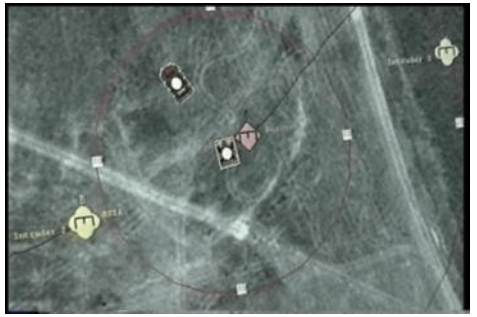
- System Integrator
  - Integration of capabilities (sensors, software, hardware) onto UGV platforms
- Technology Development and Demonstration
  - Army Technology Objectives (ATOs)
  - In-house Research and Development
  - CRADAs and SBIRs
  - Other
- Technical Evaluation
  - Evaluate technologies and capabilities for customers like RSJPO
- Soldier Experiments
  - Support experiments and tests at locations like Ft. Benning
- Feed Requirements Generation

Near Autonomous Unmanned Systems (NAUS) ATO

Purpose:
Increase the level of autonomy of Unmanned Ground Vehicles (UGVs) toward operational consideration

Products:
- **Near-autonomous UGV operations in dynamic environments**
- **Near-autonomous dynamic UGV/MGV Tactical Formations**
- **UGV System Self Security through pedestrian Intent inference**





Robotics Collaboration (RC) ATO

Purpose: Develop the tools, techniques, & autonomy to maximize mounted and dismounted control of ground and air unmanned systems and optimize Soldier-robot and robot-robot ground and air teams

Scalable Interface:

– Increased scalability, portability and tailorability of Soldier Machine Interface—reduces training burden

– Control multiple unmanned system– one device can support unique robots from different vendors

Driving Aids:

– Enables Soldiers to take actions of a semi-auto vehicle while staying in obstacle avoidance

– Increased mission OPTEMPO, reduced intervention times

– Provides Situational Awareness of unmanned system

– Increased insight in unmanned system planning activities

Improved Mobility and Operational Performance through Autonomous Technologies (IMOPAT) ATO

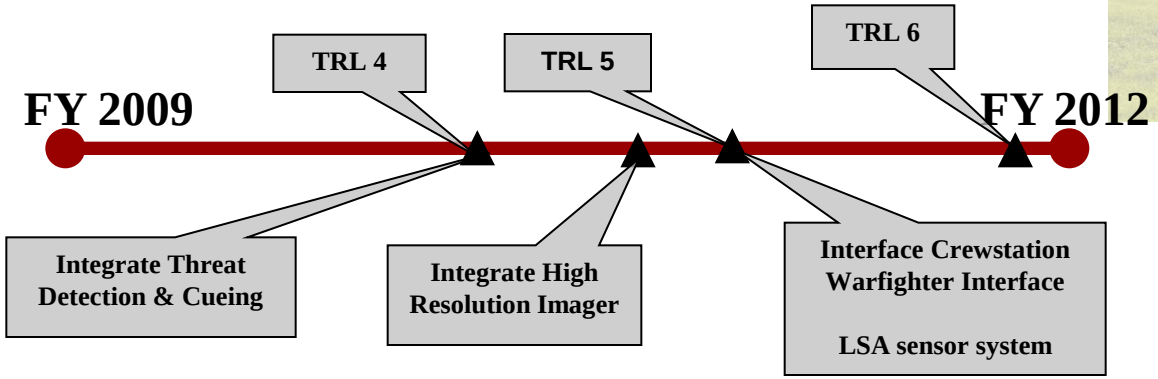
360/90 Day/Night
Near-field Sensor Coverage

Soldier Monitoring
& State Classification

Advanced
Crew Stations

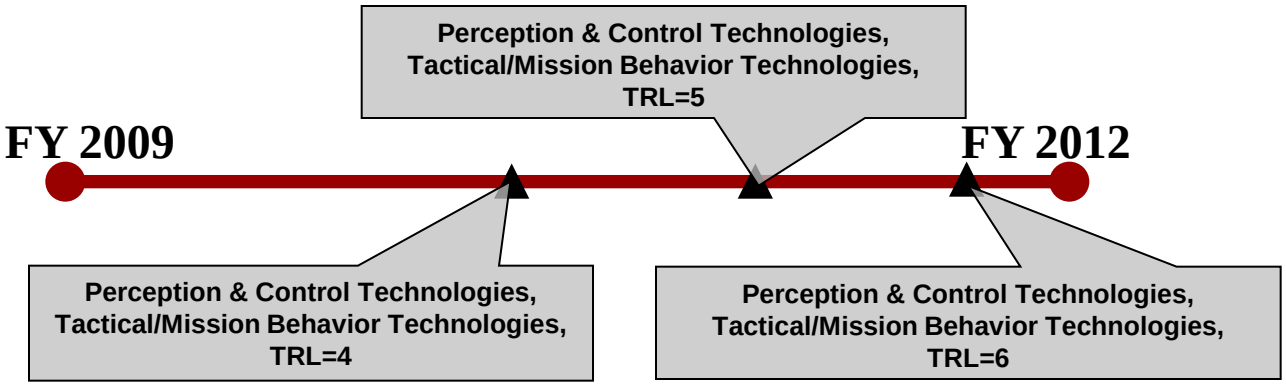
- Focus on closed-hatch operations, indirect vision
- 360/90 degree local area awareness
- Improved mobility via non-LADAR and LADAR based solutions
- Improved assessment and integration of operator performance in real-time
- Increase situational awareness for all crew members

Enhance, Integrate and Demonstrate 360/90 LSA/Assisted Mobility/Human Dimension to Maximize Indirect Vision 360/90 LSA and Mobility Capabilities (Secure Mobility)



Safe Operations of Unmanned systems for Reconnaissance in Complex Environments (SOURCE) ATO

- Safer operations of UGVs in proximity to pedestrians and vehicles
- Increase in vehicle autonomy to enable less supervisory burden
- Increased UGV situational awareness
- Robust Soldier/robot and robot/robot teaming behaviors
- Robust UGV performance in all environments/conditions
- Simulation of platform, payload and algorithms in relevant operational environment



Convoy Active Safety Technologies (CAST)

Program Goals:

- **Provide low cost ($10-20K) convoy automation (Leader/Follower) capability for current force Army vehicles**
- **Support Warfighter requirement for convoy automation and active safety**
- **Provide Robotics capability in CS/CSS community**
- **Leverage RF, RDECOM and other FCS Technologies**

Enhanced Soldier Protection

- Increased Situational Awareness
- Reduced Collisions
- Reduced crew driving tasks
- Reduced fatigue
- Increased Driver Cognition

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Safe Operations (SafeOps)

Program objectives:

- **Increase Soldier Directly address risks associated with employing UGVs in dynamic environments**

- **Identify risk areas of operating UGVs around moving traffic, pedestrians & dismounted forces**

- **Integrating FCS representative technologies**

- **Dismounted forces safety**

- **Maintain lane among civilian traffic**

- **Develop the tools, techniques & autonomy to maximize mounted & dismounted control of ground and air unmanned systems and optimize Soldier-robot and robot-robot ground & air teams**

Following, Awareness, Safe-Ops, and Tracking through Intelligent Ground Systems (fastIGS)

Purpose:
Integrate, enhance, and demonstrate a 360° Spatial Awareness System using Ultra Wide Band for Dismounted Following and Mounted Autonomous Tactical Behaviors.

Payoff:
Drastically minimizes the amount of soldier intervention required to take unmanned systems along in dismounted operations. Provides 360° Spatial Awareness for all assets in the system (manned and unmanned).

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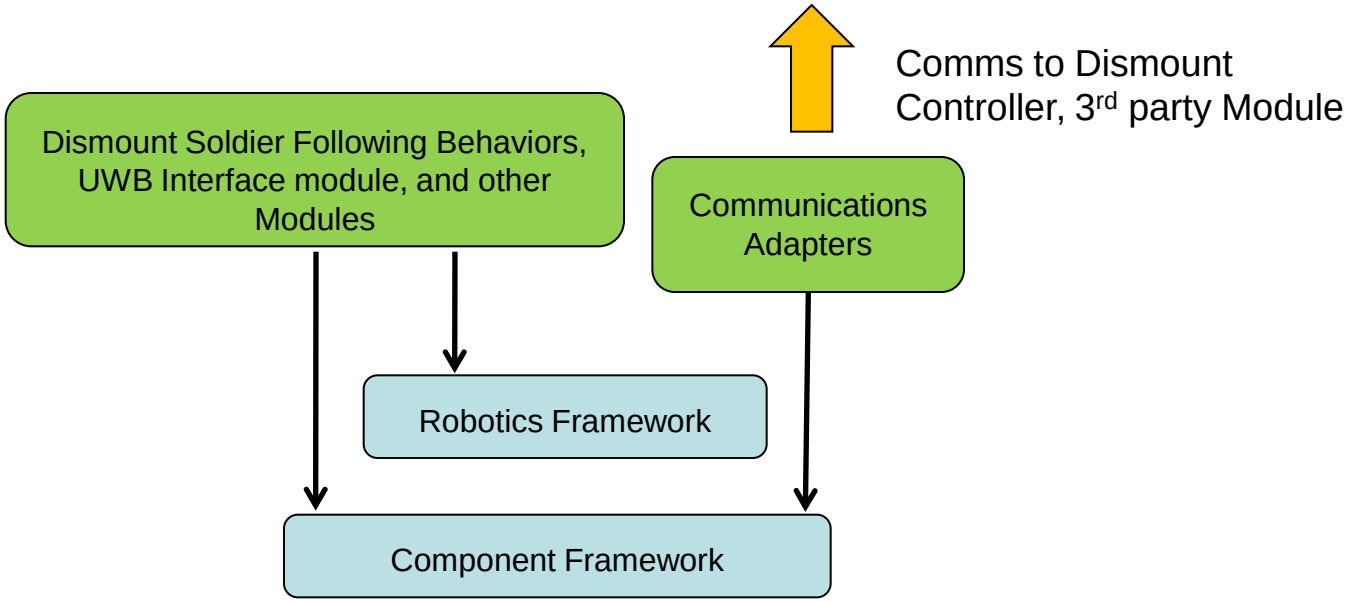
fastIGS - Overview

- Problem:
  - Robotic platforms require a lot of Soldier interaction, making them a detriment to most dismounted operations
  - Robotic Vehicles do not have adequate information about the formations around them to function autonomously in a tactical environment
- Purpose:
  - Integrate, enhance, and demonstrate a 360° Spatial Awareness System using Ultra Wide Band for Dismounted Following and Mounted Autonomous Tactical Behaviors
- Results:
  - Integrated and improved UWB tracking system on ATV vehicle for doing soldier tracking
  - Enhanced TARDEC's Robotic Controller to support the developed 360deg Situational Awareness and Dismounted Following
  - Upgraded ATV vehicle to use Robotics Intelligence Software and added control for UWB dismount following

fastIGS - Architecture



fastIGS – Behaviors and Modules

- Simple Tele-operation behavior
  - Subscribe to steer angle and speed publication from the Dismount Communications adapter module
  - Parameters set with script like maximum velocity and maximum steer angle
  - Evaluate outcomes from behavior system assess utility against desired speed and steer command values
  - Vote for action within behavior system, weighed against other behaviors like obstacle avoidance
- Dismount Follower behavior
  - Set follow distance, speed using parameters in script
  - Subscribe to Soldier locations from UWB interface module (provides UWB positions), identify leader using published leader id from Dismount Communications adapter module
  - Follow leader – simple point towards leader and follow (does not follow path)
- Other Modules
  - Mode manager to track and set mode of operation (tele-op, follow, idle, etc)
  - Module that interacts with UWB positioning system, communications to dismount controller

fastIGS – Testing at Ft. Benning (video)

fastIGS – 3rd party module integration

- Prototype navigation module from Phase II SBIR
  - Hardware connects through Ethernet port on vehicle
  - Utilizes vision for obstacle avoidance, gesture recognition to start/stop vehicle, and UWB positioning information for following
  - Follows the actual path of the Soldier that is identified as the leader
  - Gesture recognition syncs with UWB positions to determine the leader id
- Created a module utilizing the robotics intelligence software framework that adapts between the robotic intelligence software framework pub/sub system and the module, using Joint Architecture for Unmanned Systems (JAUS) standard
- Example of one way TARDEC IGS can help foster integration of different technologies

Working with TARDEC/IGS

- Cooperative Research and Development Agreement (CRADA)
- Small Business Innovative Research (SBIR) program
- TARDEC Ground Vehicle Portal
- Joint Center for Robotics (JCR)

CRADA Overview

- Between Government Laboratories and commercial, academic, government or association partners
- Facilitate technology transfer between the parties
- Partner contributes personnel, services, property and funding
- Government contributes all the above, except funding
- More information can be found at http://tardec.army.mil/briefings
  - Dual-Use Briefings – CRADA Overview

SBIR - Overview

- Purpose
  - Federal Government wide program
  - Increase small business participation in federally funded R&D
  - Transition Federal R&D into government programs and industry initiatives
- Requirements
  - Be a U.S. for-profit small business of 500 or fewer employees
  - All work must be performed in the United States; including subcontractors
  - During Phase I, a minimum of 2/3 of the effort must be performed by the proposing small business; a minimum of ½ of the effort in Phase II
  - Principal investigator must spend more than ½ of the time employed by the proposing small business
- More information can be found at http://tardec.army.mil/briefings.asp
  - Dual-Use Briefings – SBIR Overview

SBIR - Overview

Topic

- A Technology Requirement

Phase I

Feasibility Study
- 6 Months
- $70K,
- 10% proposals selected

Phase II

Prototype Development
- 2 Years
- $780K
- 50% selected

Phase III

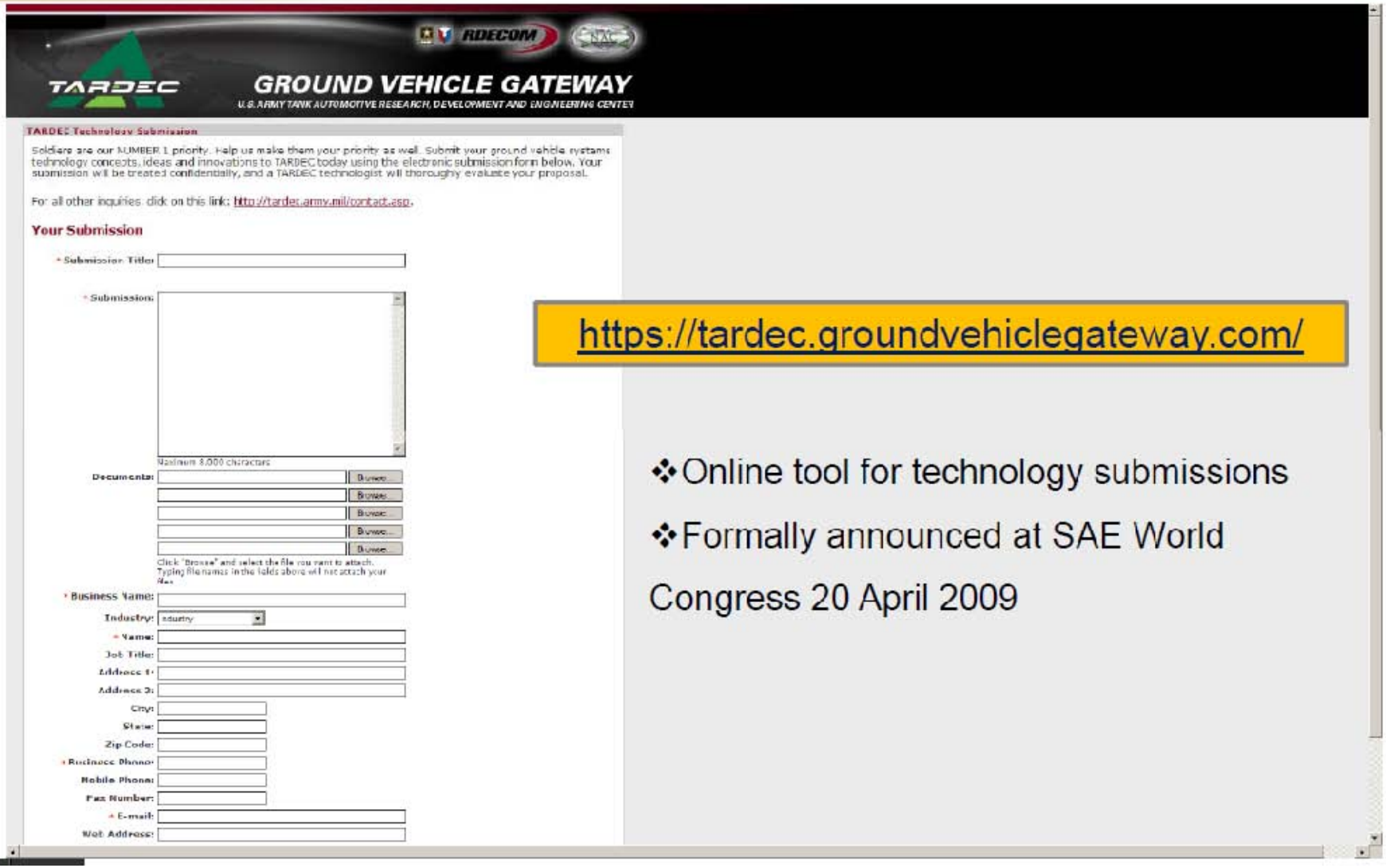
Transition
Non-SBIR Funds
- Government
- Industry

Phase I + Phase II = $850K

SBIR – IGS Topics (2009.3)

- Semi-autonomous Manipulator Control
- Autonomous Indoor Mapping and Modeling
- Improved Tele-Control for Manipulator Equipped Unmanned Ground Vehicles
- Standards Based Unmanned Ground Vehicle Mission Translator with Graphical Planning Tool
- Vision-Based Motion Sensing for Small Unmanned Ground Vehicles
- Teleoperation with High Latency

TARDEC Ground Vehicle Gateway



https://tardec.groundvehiclegateway.com/

- Online tool for technology submissions
- Formally announced at SAE World Congress 20 April 2009

Joint Center for Robotics (JCR)

- S&T Support to the RS-JPO
- Develops and Fosters external Relationships
- Matures technology for Insertion into ATO programs
- Robotics Outreach
- RS JPO Collaboration Cell Lead
- Support to IGS Capability Cells
- Robotics Academic Programs (Including Curriculum Development)

Government Partnerships	Industry Partnerships	Academia Partnerships	Community Outreach
TRADOC	Delphi Ford Foster-Miller General Dynamics GM Google iRobot JADI John Deere Lockheed Martin Oshkosh Polaris Quantum Signal Raytheon Soar Technology Think-A-Move Toyota	Auburn University Carnegie Mellon Lawrence Tech. University Michigan State University Michigan Tech MIT Oakland University University of Detroit Mercy University of Michigan U of M Dearborn Virginia Tech Wayne State University	TARDEC Robotics Quarterlies Robotics, Engineering and Technology Days

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Questions?